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ABSTRACT

Use of the Optacon, a reading aid for the blind, was explored in regard to user occupations, factors affecting reading speed, and how the machine is used on the job. Data were obtained from a survey of 250 Optacon users; from statistical analyses of information gathered about 41 Optacon trainers; and from a telephone survey of 17 blind people in different occupational groups who use the Optacon as a job tool. Results included findings that students, housewives, computer professionals, social workers, and business personnel are major Optacon users; that young people read more quickly at the end of Optacon can be a useful tool in any occupation where retrieval of printed information is useful; that persons in entry-level positions are strongly motivated to use the Optacon on the job; and that the Optacon enables users to plan and to organize their work more efficiently. (LH)

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AN ANALYSIS OF OPTACON USAGE

By Loren T. Schoof, II*

ABSTRACT

This paper explores three topics which relate to Optacon usage. The first topic is the categorization of Optacon users according to occupation. Where relevant, the data presented here are compared with those of the earlier AFB survey (Goldish and Taylor, 1974). A major change is that students have become the largest group of Optacon users, replacing computer professionals. However, a wide range of occupational categories is represented and a breakdown is given for those people trained at Telesensory Systems, Inc.

The second topic is a statistical anlalysis of factors which affect the performance levels attained by the end of the TSI training course. A total of 41 participants in this course during 1973 and 1974 form the data base for this analysis. Two variables were considered as measures of performance: Optacon reading speed and letter recognition. The latter proved to be unsuitable for statistical analysis. The factors which were analyzed for their effect on Optacon reading speed were age, sex, age of onset of blindness, and braille reading speed. An analysis of variance showed that the only factor which had a statistically significant effect was the age of the participant at the time of training. The results of this analysis have been updated with seventeen additional participants. It is also shown that, during the time period under investigation, there appears to be no significant change in the effectiveness of the training courses.

The final topic of this paper is a description of how people in different occupational groups are using the Optacon on the job. Although the results are qualitative, it does appear that those in entry-level positions are more strongly motivated to take advantage of the Optacon on the job. People past the entry-level position seem to find the Optacon enables them to plan and organize their work more efficiently. The ability to read confidential information without assistance of another person also appears to be of importance to Optacon users. All of the people interviewed felt that the Optacon was of significant value to them in their employment.

INTRODUCTION

Since the Optacon (a portable, direct translation, inkprint reading aid for the blind) first became available in 1971, a number of studies and surveys have been conducted on topics related to the process of learning to use it as well as its application. Tobin, et al (1973) and Weisgerber, et al (1974) have attempted to identify predictors of performance in an Optacon training course. Goldish and Taylor (1974) have surveyed Optacon users to determine how important the Optacon has proven to be in daily life.

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Editor's Note: Mr. Schoof, who is blind himself, performed all of the statistical analyses he describes in this paper with an Optacon, HP-35 calculator, and a Perkins Braillewriter as his only aids.

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The studies relating to Optacon learning have tended to follow the same pattern. The researcher develops a set of training methods and materials based upon his own theory of education and his assumed performance criteria. He then selects a group of subjects who have different levels of characteristics which he believes may affect Optacon learning. The subjects are briefly trained toward these performance criteria with the Optacon according to the methods he has developed. At the end of training, measurements of variables which reflect achievement according to these performance criteria are obtained. An analysis is performed to ascertain which factors have a statistically significant effect on Optacon performance. The Optacon students are then dismissed without any assurance of access to an Optacon no matter what their performance in the training.

Telesensory Systems training methods have been developed through an iterative process. They are intended to help the student integrate the Optacon into his daily life as quickly as possible. At the end of training, a student knows that the Optacon will be his no matter what his performance during the course. Since the student will retain use of the Optacon after training, there would seem to be significantly more motivation for a student to learn to use the Optacon in this situation. However, the TSI training courses are individualized to each student's desires and needs. For example, if a student and the teaching staff decide it is more appropriate, in relation to the student's projected needs, to emphasize instruction on the format of certain documents rather than on speed building, the resulting course will reflect this emphasis. Thus, because these courses are designed to provide a service to the blind individual rather than fulfill a research purpose, the goals of the training vary according to each individual's needs.

Approximately one year ago, the American Foundation for the Blind conducted a survey of Optacon users (Goldish and Taylor, 1974). Among other topics covered was a breakdown of Optacon users by occupation. Since that survey, a number of Optacon dissemination programs have been undertaken. These programs have made it possible for people who would not otherwise be able to afford an Optacon to do so. These programs may have significantly

changed the occupational distribution of Optacon users. Also, a number of questions have been raised about the suitability of the Optacon in some occupational situations. Based on brief studies of Optacon learning and on interviews with newly trained users, some researchers have made claims about the appropriateness of this device which would seem to be no more than conjecture (e.g., see Tobin, et al, 1973).

In view of the problems cited above with previous Optacon-related research, it seemed appropriate that another paper be prepared which would take into account some of these problems. The survey of occupations of Optacon users has been updated to reflect the rapid increase in the number of Optacon users. A statistical analysis of Optacon learning of TSI trained students has been done. However, the variables in this type of analysis do not necessarily reflect the utility of the Optacon to a blind person. To overcome this problem, a series of in-depth interviews are presented which give a greater feeling for how people in different occupations are using the Optacon.

PART I -- OCCUPATIONS OF OPTACON USERS

Before coming to TSI for training, each Optacon student fills out a personal information form. One of the questions concerns the student's occupation at the time he receives Optacon training. From this and from other sources, the occupations of 250 Optacon users were determined. Table I summarizes this information in terms of percentage of the sample for each occupational group together with the corresponding information from Goldish and Taylor, 1974.

While this is by no means an exhaustive sample of all Optacon users, it does give some idea of the occupational groups which are taking fullest advantage of the Optacon. Since the AFB survey, there are two changes worth noting: (1) students have replaced computer professionals as the largest single group using the Optacon, and (2) housewives have now replaced business and clerical workers as the fourth largest occupational group using the Optacon. The increase in the number of students using the Optacon can probably be explained by the growing interest of school systems in providing Optacons and

Table I

Occupations of Optacon Users (General)

Occupation	TSI Sample (Per Cent)	AFB Survey (Per Cent)
Student	25.90	20
Computer Professional	22.31	23
Social Worker (Counselor or Administrator)	17.13	14
Housewife	12.79	8
Business (Clerical and Administrative)	11.55	13
College Professor or Administrator	3.98	4
Teacher (Elementary and Secondary)	2.39	--
Attorney	3.59	3
Engineer and Scientist	1.99	5
Other	0.80	8

Optacon training, and by the program of the Richard King Mellon Foundation. This program has allowed many people such as students and housewives to obtain what would otherwise be a prohibitively expensive piece of equipment.

Within each of these broad occupational categories, there is a wide diversity of possible job definitions. For the sample of 250 Optacon users, a more detailed breakdown of occupations was not possible. However, for those students trained at TSI, Table II gives a more specific breakdown of their occupations. In addition to those listed in the table, a television producer, a braille proofreader, and a meteorologist with the National Weather Service have become Optacon users.

PART II -- STATISTICAL ANALYSIS OF TSI TRAINING COURSE DATA

The data used in this analysis was gathered from July 1973 through February 1974. The people who come to TSI for Optacon training are not considered to be subjects in an experiment. They have paid a fee to attend the course and have, either through purchase or other means, guaranteed access to an Optacon at the end of training. The objective of Optacon training is to enable them to use the Optacon on the job and in other daily activities.

Optacon trainees were asked to take tests which would measure the variables used in this analysis. They were not required to do so and, in

Table II

Occupations of Optacon Users (Detailed)

Students		Professional	
Elementary (6 - 13 years)	5	Engineering	4
High School (14 - 17 years)	1	Physicist	1
College (18 - 21 years)	21	Attorney	4
Graduate School	11	Teacher (Elem & High School)	5
Housewives	3	Librarian	1
Business		Psychologist	2
Receptionist	2	Sociologist	1
Dictaphone typist	3	School Coordinator	1
Secretary	2	College Professor	5
Technician	2	College Dean	2
Assembler	1	High School Counselor	1
Systems Analyst	3	Counselor	3
Programmer	43	Rehab Director/Center	1
Information person	1	Rehab Administrator	5
Expediter	1	Rehab Teacher	8
X-ray film processor	1	Rehab Counselor	8
Finance	1	Newscaster	1
Personnel	1	Minister	1
Taxpayer Service Rep	1	Foreign Veteran	1
Field Rep for Company	1	Coffee Shop Owner	1

fact, a number of individuals refused. Out of the total number of people trained during this time period, 41 data points were obtained. After the majority of the analysis had been completed, an additional 17 data points from the March, April, and May classes of 1974 were used to further update the resulting model. The actual number of students trained in that period was somewhat larger.

As with any statistical analysis, the results here apply only to the data upon which they are based. Any extension of them to other individuals must be based on the assumption that these results are true in general as well as for the sample analyzed. Furthermore, these are results at the end of a nine-day training course. They give no indication of what happend to Optacon reading performance after additional practice. To date, no quantitative follow-up studies have been done.

Training Procedures

Optacon training at TSI is an intensive course oriented to the needs of blind adults. Fifty to sixty hours of instruction are spread over nine class days. A one-to-one student/teacher ratio is maintained at all times. Teacher assignments are so arranged that the student works with a different teacher each day. A logging procedure has been developed so that each new teacher is familiar with the student's prior progress. The course work centers on five principal areas: equipment operation, letter recognition, tracking, speed building, and the format of common materials. These are not taught as separate topics, but must frequently overlap with one another. Letter recognition, for example, involves some practice in tracking

The first area covered is the operation of the Optacon. The student learns the location and function of each of its controls. He learns how to adjust these controls to produce the best possible image on the tactile screen for the materials to be read. The teacher usually helps the student with the adjustments during the first few lessons.

Almost from the beginning, the student learns to recognize letter shapes and to synthesize them into words, phrases, and sentences. The materials used to introduce the student to print letters are in a simple, sans serif type font. Care has been taken to insure that this initial printing is as clear as possible. These measures allow the student to concentrate on the primary task of letter recognition. Later, as he becomes more skillful, other type styles and poorer quality print can be introduced. Upper case letters are introduced first since they seem to be more easily learned. The format of the lessons, however, is the same for both upper and lower case letters.

In general, a test is given at the beginning of a lesson to make certain that the student can identify letters that have previously been learned. If he is successful with this, a few new letters are introduced. A maximum of eight new upper case or five new lower case letters appear in a single lesson. After the student is satisfied that he can identify the new letters, another test is given. At the discretion of the teacher, the student can move to the next lesson or work with optional practice material included in the lesson. After a few letters have been learned, lessons are included which combine

these letters into short words and sentences. As new letters are mastered, they are used in these practice lessons along with those letters previously learned.

Tracking, the skill of moving the camera across printed material, is developed concurrently with the letter recognition and speed building aspects of Optacon training. The first lesson a student encounters is designed to show him the stimulation from the tactile screen and the effect that camera movement has on that stimulation. At the start of training, the student uses a tracking aid to make this task somewhat easier. This device allows him free movement of the camera in the horizontal direction while restricting its vertical motion. As the student's ability to relate camera motion to the image on the tactile screen improves, the restriction on the vertical motion of the camera is relaxed. Finally, the student moves the camera freely without the use of a tracking aid.

The latter stages of the training course are devoted to helping the student integrate the Optacon more rapidly into his daily activities. This help is in two main areas: increasing the student's reading speed and familiarizing him with the format of materials he will frequently be using. In the first of these areas, a number of short stories have been included in the materials used at TSI. These stories allow the student to practice both his reading and tracking skills.

A piece of equipment, the Automatic Page Scanner, is also used in training. It moves the Optacon camera across a page of printed material at a fixed rate of speed. This relieves the student of the tracking task. He is forced to spend less time on recognizing individual letters. Instead, he must try to read whole words and to use context to anticipate new material.

The student can make more effective use of the Optacon if he can take advantage of the special formats of some printed materials. Samples of formats such as dictionary pages, bank statements, computer listings, and memos are indluced in the training materials. The teacher can show the student how to take advantage of the format to quickly find important information. Students who come to TSI for training are also encouraged to bring samples of the materials they are interested in reading.

A more detailed description of Optacon training at TSI can be found in the Teaching Guidelines manual listed in the bibliography. Methods described here are the result of experimentation and revision over a period of several years. Some of the papers listed in the bibliography show how the direction and emphasis in Optacon teaching have changed over the years (Weihl 1970, Hill and Baer 1972). No lesson plan or teaching technique has been pre-ordained as the one absolutely correct method. Indeed, the procedures outlined above will continue to be revised as additional experience is acquired.

Choice of Variables for Analysis

The only truly valid measure of Optacon learning is the extent to which an individual trained in its use becomes dependent on it. This is, however, difficult to measure in a quantitative manner. The variable most commonly used as a measure of performance in training has been Optacon reading speed. This variable was used in the English Optacon evaluation (Tobin, et al, 1973) and in the Office of Education evaluation (Weisgerber, et al, 1974). Weisgerber also used a letter recognition test as a measure of reading accuracy. Both of these variables were measured for use in this analysis.

Since this was not an experimental program, it would have been difficult to insist that Optacon students undergo a battery of physical and psychological tests. The variables selected for their possible effect on Optacon learning performance had, therefore, to be measurable without undue imposition on the students. Braille reading speed, for example, seemed to be a reasonable, if crude, measure of tactile sensitivity. Tobin, et al (1973) found that this variable was significantly correlated with Optacon reading speed. Weisgerber, et al (1974), however, found that there was no relationship between braille reading speed and Optacon reading speed. They did report a relation between this variable and Optacon reading accuracy. Tobin also found a significant relationship between age and Optacon reading speed. This variable was also included in the present analysis. As early as 1970, there was some interest in the possible influence of past visual memories on Optacon reading (Hill and Baer 1972). This variable was used by Tobin in his Optacon evaluation. Based on a subjective feeling that it might have some effect, sex was also considered as a factor.

Measuring Variables

Age, sex, and age of onset of blindness were determined by a questionnaire. Braille reading speed is tested on the first day of class. Each student works in a separate room and on a one-to-one basis with his instructor. The student is given three short stories in standard grade 2 braille. He reads each story silently. The instructor checks for comprehension and, using a stop watch, records the time it takes to read each story. After classes are finished, the three times are used to compute the average braille reading speed for each student.

Letter recognition and Optacon reading speed are measured on the final day of training. Again, the instructor works alone with the student. As in training, a Visual Display is connected to the Optacon so the instructor can monitor the student's performance. Reading speed is tested using a five-paragraph story. The teacher reads the first paragraph aloud. The second is read aloud by the student with the instructor helping when necessary. At this point, the student should have some idea of the context of the story. He then reads the remaining three paragraphs silently with the instructor recording the time taken for each. These three times are later used to compute the average reading speed. As with the braille test, the teacher checks for comprehension.

Letter recognition is tested using exercises from the training material. Specifically, a criterion test from Lesson 9 is used for upper case letters and one from Lesson 20 for lower case. The student moves the camera himself as he identifies each letter. The instructor records his answer without telling the student whether or not it is correct. There is no time constraint and the student may only scan each letter one time. The percentage of letters correctly identified is used as the letter recognition score.

Using standard estimators, the means and standard deviations for these variables were calculated. The value "1" was used for a male and "0" for female. Table III summarizes the information about the sample.

Table III

Characteristics of TSI Student Population

Factors	Mean	Standard Deviation
Age (years)	30.12	9.57
Sex	0.707	.461
Age of Onset of Blindness (years)	5.63	10.62
Braille Reading Speed (words/min)	101.35	48.38
Optacon Reading Speed (words/min)	9.61	4.65
Letter Recognition (% correct)	0.931	0.051

Distributions of the Measured Variables

To perform an analysis of variance on either Optacon reading speed or letter recognition, that variable must be normally distributed. Chi-squared goodness or fit tests were used to check this hypothesis. Optacon reading speeds ranging from zero up to 20.22 words per minute were observed at the end of the training course. For the chi-squared test, the interval from zero to 22 was divided into 11 equal two-unit segments. The hypothesis tested is that, on this interval, Optacon reading speeds are normally distributed with estimated means of 9.16 and standard deviation of 4.65.

Table IV shows both the observed and predicted number of reading scores in each interval. The predicted numbers have been adjusted so that the normal distribution is completely restricted to the interval from zero to 22.

Table IV

Histogram of Optacon Reading Scores

Interval	Observed	Predicted
0 - 2	1	1.58
2 - 4	4	3.02
4 - 6	8	4.84
6 - 8	6	6.45
8 - 10	7	7.17
10 - 12	3	6.65
12 - 14	6	5.13
14 - 16	3	3.30
16 - 18	1	1.77
18 - 20	1	0.79
20 - 22	1	0.30

Based on these figures, the calculated chi-squared statistic is 6.832 with eight degrees of freedom. At the 5% level, the predicted chi-squared equals

15.507 so the hypothesis is accepted at this level. In fact, the hypothesis is finally rejected at the 70% level where chi-squared equals 5.527. This suggests that the hypothesis of a normal distribution is very strong.

Letter recognition test scores ranged from 0.500 up to 0.993. All but four of the people tested had scores between 0.900 and 1.000. The interval 0.500 to 1.000 was divided into seven unequal intervals so that most of the intervals could be in the range where most people scored. The hypothesis is that letter recognition scores are normally distributed with an estimated mean of 0.931 and standard deviation of 0.051. Table V summarizes the observed and predicted number of scores in each interval. Again, the predicted values have been adjusted to restrict the normal distribution to the interval being tested.

Table V

Histogram of Letter Recognition Scores

Interval	Observed	Predicted
0.50 - 0.80	1	0.23
0.80 - 0.90	3	11.96
0.90 - 0.92	8	6.39
0.92 - 0.94	9	7.30
0.94 - 0.96	7	6.32
0.96 - 0.98	7	5.21
0.98 - 1.00	6	3.60

From these figures, the calculated value of the chi-squared statistic is 12.380 with 4 degrees of freedom. At the 5% level, the predicted value of chi-squared is 9.488, so the hypothesis of normal distribution is rejected. The hypothesis would be accepted at the 1% level where chi-squared is 13.277.

Another area to be tested is the statistical independence of the letter recognition and Optacon reading speed variables. A chi-squared test of this gives a chi-squared value of 86.394. The predicted value of chi-squared at the 5% level is 79.082 with 60 degrees of freedom. The hypothesis is rejected at this level. It would finally be accepted at the 1% level where chi-squared is 88.379.

Since letter recognition is neither normally distributed nor independent of Optacon reading speed, it did not seem appropriate to include in in further analysis.

Correlation Coefficients

In the regression analysis, a set of linear equations is solved to yield the coefficients. In solving these equations, it is helpful to the analysis of variance if the factors most likely to be statistically significant are solved for first. The correlation coefficients have been calculated in an attempt to get a rough measure of the significance of each factor. The factors will be ordered according to which one has the largest absolute value of its correlation coefficient. These correlations are also of interest in themselves as they sometimes disagree with the results of analysis of variance.

The standard estimator for the correlation coefficient has been used. This estimator is derived from the bivariate normal distribution. The t statistic is used to test the hypothesis that the correlation coefficient is statistically equivalent to zero. The variable for Optacon reading speed has already been shown to have a normal distribution. Although tests have not been made, it appears that age and braille reading speed are also normally distributed. On the other hand, the distribution of sex within the sample has a demonstrably binomial form. An examination of the data also suggests that age of onset of blindness would probably have a distribution represented by a decaying exponential. In this case, the correlation coefficients and the statistical tests on them are only a very rough guide to the significance of these factors.

Table VI shows the correlation with reading speed and the calculated t statistic for each factor.

Table VI

Correlations With Optacon Reading Speed

Factors	Correlation Coefficient	t
Age	- 0.6047	5.74
Sex*	- 0.3248	2.14
Age of Onset of Blindness	- 0.3441	2.19
Braille Reading Speed	0.0672	.402

*Negative value indicates that females had higher reading scores.

The equation for the regression analysis will be ordered as in the table above. Although the coefficient for age of onset of blindness has a slightly

larger magnitude, sex was solved for first on the basis of an earlier analysis and with a smaller sample.

All of the t statistics have 39 degrees of freedom. At the 5% level, the t distribution has the value 1.685. From this, it appears that only for braille reading speed would the hypothesis of a zero correlation be accepted. Braille reading speed would become significant at the 40% level where t equals 0.255. At the 1% level, t equals 2.426. Hence, sex and age of onset of blindness would have zero correlation at this level. At the .05% level, t equals 3.561 so that age still has a non-zero correlation.

Regression Analysis

To construct a linear model for Optacon reading speed, coefficients of the normal equations had to be calculated. For a number of reasons, it seemed better to break each factor up into a set of variables which take the values zero and one only. The definitions of the controllable variables are given below.

Age. From earlier analysis with a smaller sample, it was clear that there was an extremely sharp break between people above the mean age and those below it. It seemed reasonable then to use a set of discrete levels to more accurately represent the situation. These variables take the value one in the indicated age range and are zero otherwise as follows:

z_{11}	those under 20 years of age
z_{12}	those between 20 and 30
z_{13}	those between 30 and 40
z_{14}	those over 40

The reading speeds within each of these age ranges appear to be more consistent than would be the case with a smaller number of levels.

Sex. This factor has an obvious two-level representation. For this analysis as for the correlation coefficients:

$$z_2 = \begin{cases} 1 \text{ for male} \\ 0 \text{ for female} \end{cases}$$

Age of Onset of Blindness. This factor was divided into three levels. These levels were based on the point in education at which people became blind.

z_{31} those blinded early in their education, under 10 years of age

z_{32} those blinded during the main part of their education process, between 10 and 25

z_{33} those blinded after the major portion of their education, over 25.

Braille Reading Speed.

z_4 those at or below the mean braille reading speed.

Using these variables, the matrix which results from the normal equations is as follows:

3.61	-1.95	-1.17	-0.49	0.17	-0.32	0.71	-0.39	-0.15	20.74
-1.95	10.24	-5.85	-2.44	-3.15	1.41	0.54	-1.95	2.27	33.07
-1.17	-5.85	8.49	-1.46	1.51	0.05	-0.88	0.83	-1.44	-28.76
-0.49	-2.44	-1.46	7.39	1.46	-1.15	-0.37	1.51	-0.68	-25.70
0.17	-3.15	1.51	1.46	8.49	-2.05	0.88	1.17	-4.56	-27.86
-0.32	1.41	0.05	-1.15	-2.05	5.80	-2.49	-3.32	3.76	12.90
0.71	0.54	-0.88	-0.37	0.88	-2.49	2.78	-0.29	-1.61	6.32
-0.39	-1.95	0.83	1.51	1.17	-3.32	-0.29	3.61	-0.02	-22.11
-0.15	2.27	-1.44	-0.68	-4.56	3.76	-1.61	-0.02	10.20	8.32

The first term of the linear model is equal to the mean 9.16. When the matrix is solved, the resulting linear model for Optacon reading speed, x, is:

$$x = 9.16-2.84(z_{11}-0.098)-6.72(z_{12}-0.488)-10.46(z_{13}-0.293)$$
$$-13.31(z_{14}-0.122)-0.74(z_2-0.707)-2.18(z_{31}-0.829)-2.36(z_{32}-0.073)$$
$$-3.83(z_{33}-0.098)+0.08(z_4-0.0537)$$

Analysis of Variance. It is possible that some of the factors solved for do not, in fact, help in predicting the person's reading speed. The analysis of variance technique can be used to determine if some of the coefficients are statistically equivalent to zero. The technique involves the division of the sum of squares into parts corresponding to each variable. The remainder is the error term and can be used as an estimator for the standard deviation of the error distribution. Table VII gives the results of the analysis of variance.

Table VII

Analysis of Variance of Optacon Reading Speed Predictors

SS is the sum of squares. DF is the degrees of freedom which is the number of variables representing a factor in the normal equations. MS is the mean square and is the SS entry divided by the DF entry. F is the ratio of the MS entry for the error term.

Factor	SS	DF	MS	F
Mean	3440.13	1		
Age	363.64	4	90.91	6.09
Sex	21.00	1	21.00	1.41
Age of Onset of Blindness	18.50	3	6.17	0.42
Braille Reading Speed	0.03	1	0.03	0.002
Error	462.55	31	14.92	

If a particular factor is such that all of the coefficients in the linear model are zero, the F entry should be small relative to the predicted value from the F distribution. For braille reading speed $F_{\frac{1}{31}} = 4.16$ at the 5% level so that the hypothesis that braille reading speed does not predict Optacon reading speed is accepted. For age of onset of blindness, $F_{\frac{3}{31}} = 2.91$ so that this factor is also not significant at the 5% level. For sex, the predicted value of F is the same as for the braille reading speed, 4.16, so that this factor is also insignificant. At the 5% level, the predicted value $F_{\frac{4}{31}} = 2.68$ so that the coefficients corresponding to age are statistically different from zero. In fact, they remain statistically significant up to the 0.1% level where $F_{\frac{4}{31}} = 6.08$.

Since age is the only significant factor, the linear model for Optacon reading speed, x, is:

$$x = 17.27 - 2.84z_{11} - 6.72z_{12} - 10.46z_{13} - 13.31z_{14} + e$$

where e is the error term which has a normal distribution with mean zero and standard deviation 3.73.

Update of the Original Analysis

As mentioned above, data of the same kind used in the main analysis was also gathered from the March, April, and May classes of 1974. A total of 23 people were trained to use the Optacon during this time. For a number of reasons, primarily previous experience in using the Optacon, six of these people could not be used in a statistical analysis. The remaining 17 data

points were added to the original 41 to compute a new mean of 10.00 and standard deviation of 5.18 for Optacon reading speed at the end of training. Because of the earlier analysis, it was assumed that age remained a significant factor in predicting Optacon reading speed. Therefore, the linear model for mean reading speed was updated. The resulting equation is:

$$x = 14.35z_{11} + 12.37z_{12} + 7.54z_{13} + 4.62z_{14} + e$$

where e, the error term, has mean zero and standard deviation of 4.29. This equation is graphed in Figure 1 which illustrates the dramatic relation between age and Optacon reading speed at the end of the TSI training course.

Effect of Teacher Experience on Student Performance

A question was raised concerning the effect of additional teacher experience on the student's performance. To test this, mean reading speeds from sample groups at the beginning and at the end of the data collection were compared. The test was based on the assumptions that 1) the underlying distribution of reading speeds was normal, and 2) the standard deviations of both samples, although unknown, were equal. These assumptions seemed reasonable in view of the previous analysis. Ten students from the first four classes were used for the early sample, and ten from the April and May classes were used as the last sample. The students in the first group had a mean reading speed of 9.86 words per minute, and the students in the last group had a mean reading speed of 13.35 words per minute. The computed value of the t statistic was -1.469. With 18 degrees of freedom, the predicted 5% level of the t distribution is -1.734; hence, the hypothesis that mean reading speed of a later group is less than or equal to that of the early group is accepted. This hypothesis would be rejected at the 10% level where t equals -1.330. At this level, it would appear that the mean reading speed of the later group was statistically significantly higher than that of the early group.

Since age is known to be a significant factor, a t test under the same assumptions was used to determine if a significant difference existed in the mean ages of the two groups. The computed value of the t statistic is -0.758. Hence, there is no statistically significant difference between the mean ages of the two groups.

These two tests do not necessarily provide an absolute answer. However, based on them, it appears that no statistically significant change in mean reading

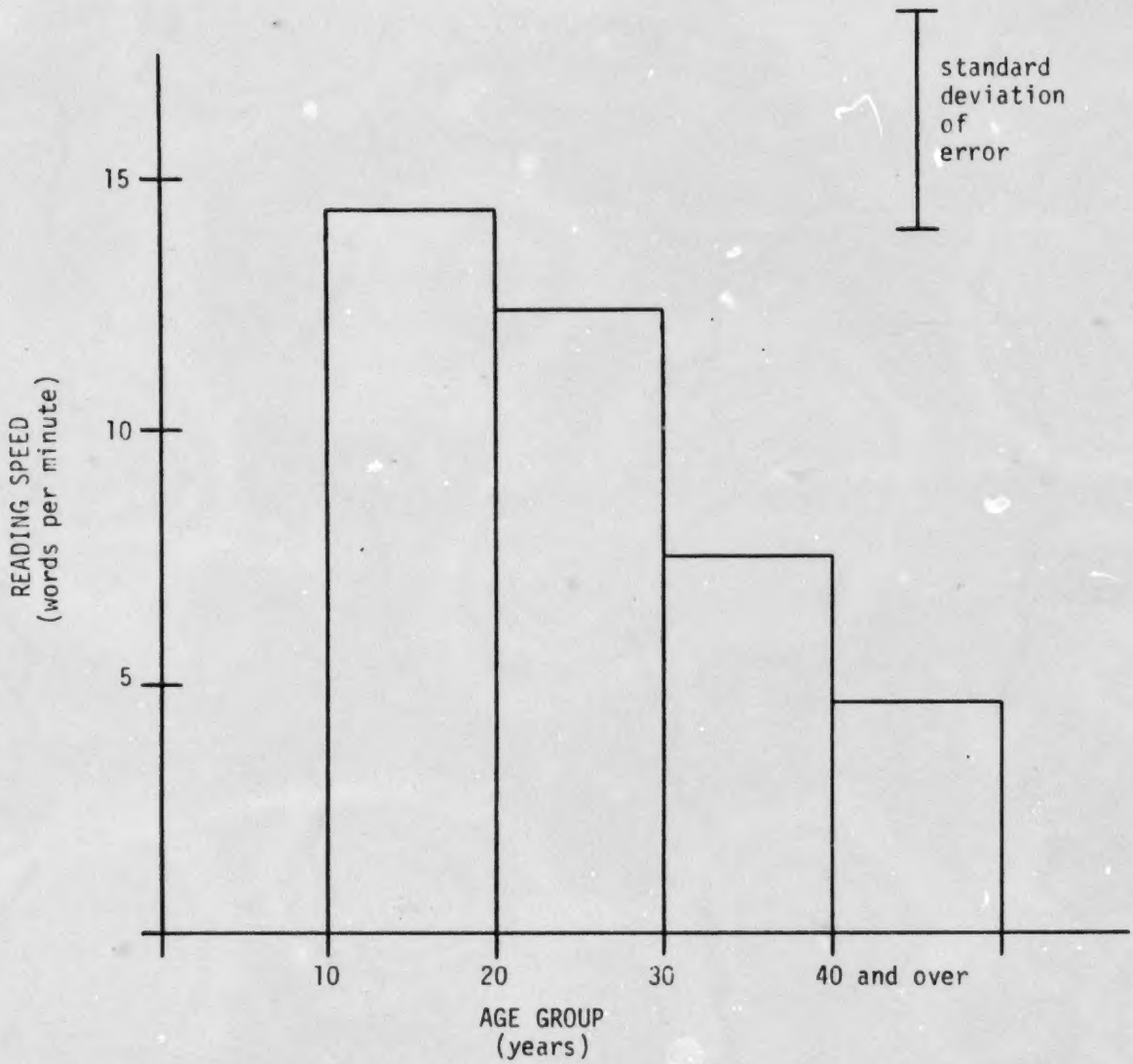

Figure 1

OPTACON READING SPEED AT THE END OF TSI TRAINING COURSE AS A FUNCTION OF AGE GROUP. Based on data from 58 students between mid 1973 and mid 1974.

speed has occurred as a result of additional teacher experience. A more detailed analysis of variance would be necessary to understand all of the effects and interactions between teacher experience and Optacon reading speed.

Implications of the Analysis

The most important result of this analysis is the negative correlation between the age of a person at the time of training and his reading speed at the end of that training. This does not imply that an older person cannot learn to read with the Optacon. It simply states that the average reading speed that can be expected at the end of training will be lower. There is, however, a reasonable probability that a person in a given age group will read more quickly or more slowly than the predicted mean. It may be that, for people over the age of 40, a less intensive, more extended period of training would be more appropriate. Also, any "screening" test which attempts to predict a person's performance in Optacon training will have to take age into account as a concomitant variable. Otherwise, the effect of this factor may overwhelm the predictive value of the test itself.

The fact that letter recognition scores do not have a normal distribution is, on reflection, not surprising. Reading with the Optacon at the end of training is a slow, almost letter by letter, process. In order to read, then, a person must be able to recognize individual letters. Even an experienced Optacon reader may be forced to examine an unusually long or unexpected word in this manner. Perhaps a more appropriate mathematical model for letter recognition scores would be a Bernoulli trial: that is, either the person recognizes letters or he does not. In light of these remarks, the interdependence between Optacon reading speed and letter recognition should be expected. The surprising part is the marginal quality of that relationship.

The correlation between sex and Optacon reading speed was statistically significant. Yet, the analysis of variance showed that this factor had no predictive value. The disagreement in the results obtained from these two methods of analysis can be explained in terms of the effect of age on performance. The average age of the women was 26.5 years while that of the men was 31.6 years. These means are on opposite sides of the population mean

which is the most significant breakpoint for Optacon reading speed. As mentioned before, the probability of a certain number of men in a sample is given by a binomial distribution. The probability of choosing a man at random in the entire US population is 0.487. Using this value, the probability according to the binomial distribution of 29 or more men in a random sample of 41 people is .00355. This would suggest that people selected by the method of Optacon purchase has not been a random process. Those women who have obtained Optacons have, on the average, been younger.

There is an even simpler explanation for age of onset of blindness having a statistically significant correlation with reading speed but not being a significant factor in a predictive model. The older a person is when he becomes blind, the older that person has to be when he is trained to use the Optacon. That is, it is a logical contradiction to have someone who lost his vision at 34 but is 25 when trained to use the Optacon. Again, the correlation coefficient is explained in terms of the significance of age.

Perhaps the most remarkable conclusion to come from this analysis is the complete lack of significance of braille reading speed. As indicated earlier, it was thought that this variable might give some indication of tactile sensitivity. Apparently, it does not. Weisgerber, et al (1974) obtained the same result. Tobin, et al, (1973), however, did find a statistically significant relationship between this variable and Optacon reading speed.

Even with age as a factor, the error term in the predictive model has a relatively large standard deviation. This implies that predictions based on this model are relatively uncertain. TSI has developed an assessment test battery which measures short-term memory, manual dexterity, and tactile sensitivity. To date, the effectiveness of this test as a predictor of performance in Optacon training has not been statistically analyzed. Hopefully, this test or some similar instrument can be developed to help assess a person's potential for effective use of the Optacon.

PART III -- USE OF THE OPTACON ON THE JOB

Part I gives some idea of the occupations where the Optacon can be used as an effective tool. To try to find out how people in different occupational groups actually use the Optacon, a telephone survey was conducted. A total of 17 people were interviewed in this manner. An attempt was made to get two people from each of the major categories shown in the first table in Part I.

The questions asked were intended to determine the amount of time the person used the Optacon each day, the kinds of materials read, and the importance of the Optacon to the person in performing his job. Information was also gathered about use of the Optacon outside of the job, estimated reading speed, and some other details about age and Optacon training. The following are brief summaries of these telephone interviews.

Respondent #1

Age estimated -- 24 - 25
Age of onset of Blindness: unknown, apparently early
Optacon training center: Vision Center of Central Ohio, Inc.
Date of training: March 1974

The respondent is currently in training to be a medical transcriber. She has already graduated from college with a bachelor's degree in linguistics. Due to the recent date of her training with the Optacon, she has not been able to make full use of it. She intends to use it as a selling point when seeking employment. Currently, she uses it to read dictionaries, personal correspondence, and other similar personal materials. She is also using the Optacon to learn to read different alphabets such as Greek and Arabic. She indicated that Arabic presented serious difficulties. Her reading speed at the end of training was 20 words per minute; she would not give an estimate of her present reading speed.

Respondent #2

Age: 20
Age of onset of blineness: 3
Optacon training center: San Diego Unified School District
Date of Training: December 1971

He is currently majoring in business administration and Spanish. He uses the Optacon to read hand-outs of class materials, announcements, and some brief passages of text. During the last school year, he used the Optacon to read all

of the materials for a course in Spanish grammar. He indicated that he was able to do this sufficiently well to complete the course with a high grade. He is very interested in using the Optacon with a pocket calculator as he believes this will help him in his business courses. He estimates his reading speed to be in excess of 40 words per minute, and says that he reads with it from an hour to an hour and a half per day. Outside of class, he uses it to read personal correspondence and materials from groups in which he participates. He will attend law school after graduation and plans to use the Optacon extensively during his studies. He stated that he is very dependent on the Optacon and would feel lost without it.

Respondent #3

Age: 26
Age of onset of blindness: 26
Optacon training center: TSI
Date of training: June 1973

The respondent is currently studying for a master's degree in social work. She uses the Optacon to read a wide variety of materials necessary in her studies. She depends on the Optacon to read class handouts, notes, tests, and some texts. She indicated that the Optacon has been extremely useful in proofreading her typing of reports and papers. She believes she uses the Optacon for an average of two hours per day. She estimates her reading speed at 40 words per minute.

During her internship work at a hospital, she used the Optacon to review charts and write-ups of previous interviews with patients. She also used the Optacon to read confidential case files. She felt that this was very important since it was difficult to obtain access to these files in any other way. She does not feel she could function in graduate school or in an employment situation without the Optacon. Her ability to use the Optacon will help her to obtain a job.

Respondent #4

Age: 38
Age of onset of blindness: birth
Optacon training center: Prof. Robert Stilwell, Morgantown, West Virginia
Date of training: early 1973

Respondent is a professor of political science currently using the Optacon an hour or more each day. His reading speed is between 40 and 50 words per

minute. He uses the Optacon for several tasks related to his university work (memos, circulated articles, etc), but would like to increase his speed. He seemed interested in the typewriter attachment as he uses the Optacon to proofread his work. He reads term papers and theses and can easily understand the organization and thoroughness of a student's research from looking at the format.

He does not feel dependent on the Optacon to do his job as he was in the same position prior to getting the machine. However, he does feel he now works more effectively and can read certain materials more quickly and organize his work more effectively.

Respondent #5

Age: 38
Age at onset of blindness: birth
Date of training: December 1973
Optacon training center: TSI

Respondent currently works as an elementary school teacher. She uses the Optacon about four hours per day and estimated her reading speed at 40 - 45 words per minute. She reads job-related material (memos, teacher's editions of textbooks) and personal items. Because elementary textbooks are frequently changed, the teacher's editions are often unavailable in other form. She uses the Optacon to find supplementary materials for the basic textbook of the course. She feels that scanning these materials is one of the most important benefits to her. She also uses the Optacon for work which she takes home from school and feels strongly that she is a better teacher because of the Optacon -- wonders how she managed without it before.

Respondent #6

Age: 29
Age of onset of blindness: birth
Optacon training center: TSI
Date of training: November 1972

Respondent works as a programmer for an oil company and uses the Optacon three or four hours per day. She estimated her reading speed at 50 to 60 words per minute but felt that the speed was not terribly important -- it is sufficient to allow her to do her job. She reads nearly all the materials for her job with the Optacon (computer listings, program specifications, computer

manuals, memos). She also uses the Optacon with a CRT terminal, but usually cannot read handwritten material. She mentioned that the Optacon had not been a strong selling point when she obtained her current job but the independence and flexibility conveyed by its possession may have helped convince her employer to hire her.

Respondent #7

Age: 28
Age of onset of blindness: 4
Optacon training center: Vision Center of Central Ohio, Inc.
Date of training: end of 1973

Respondent works as a computer programmer for the State of Ohio, uses the Optacon four to six hours per day, and estimates his reading speed at 40 to 45 words per minute. Although he has the option of receiving braille output from the computer, he uses the Optacon to read computer listings, program specifications, computer manuals, memos and notices, and only uses braille when he must scan a lengthy program written by someone else. At present, he feels he can skip between widely separated sections of a program more easily in braille; he can scan with the Optacon if necessary.

He had his present job before obtaining the Optacon but now feels he is very dependent on the machine to do his job properly and without it he would not be nearly as productive.

Respondent #8

Age: 35 - 40
Age of onset of blindness: unknown
Optacon training center: unknown
Date of training: 1972

Estimates he uses Optacon about two hours per day on the job and has a reading speed of 20 - 25 words per minute. He uses the Optacon to look up information in references and to read correspondence. He would like to be able to read pocket calculators and would also like to look at an oscilloscope display and other measuring instruments. He did not feel the Optacon was necessary in his job as he had the job before obtaining his Optacon; however, he did suggest that he now works more efficiently.

Respondent #9

Age: 33
Age of onset of blindness: birth
Optacon training center: TSI
Date of training: December 1972

Respondent works as an electrical engineer and uses his Optacon approximately two hours per day on the job. He works primarily as a technical writer and estimated his reading speed at 40 - 70 words per minute. He uses the Optacon to read interoffice materials, technical reports, references, to proofread his typing, examine circuit diagrams and amateur radio manuals. His reading speed is higher in braille, but often the materials he needs are not transcribed. He is therefore very dependent on the Optacon in his job, has no readers on his staff, and is not getting materials transcribed in any other way. He feels the Optacon is sufficient in his job.

Respondent #10

Age: 31
Age of onset of blindness: birth
Optacon training center: TSI
Date of training: April 1974

Respondent works as a lawyer for a large automobile manufacturer. He uses the Optacon one-half to one hour per day and estimated his reading speed at 25 words per minute. He uses the Optacon primarily to read summaries of court decisions, usually found in a weekly or biweekly journal. He reads his correspondence when his secretary is not available, but hopes to make better use of the Optacon as his reading speed increases. He also uses the Optacon for pleasure reading, such as sports news in the newspaper. This is not readily available to him in other forms. Since he was unable to use the Optacon for almost a month, his reading speed was probably inhibited. He does not feel the Optacon is essential for his job at this time but said that if his reading speed were faster he would become more dependent on it. He values the independence the Optacon gives him.

Respondent #11

Age: 28
Age of onset of blindness: birth
Optacon training center: Cleveland Society for the Blind
Date of training: November 1972

Respondent works as a lawyer in a small law firm. He uses the Optacon about four hours per day, frequently much longer, and estimated his reading

speed at more than 50 words per minute. He uses the Optacon for almost all reading done on the job (trust agreements, federal statutes, law journals, contracts, correspondence), but prefers longer materials to be read to him. He is completely dependent upon the Optacon in his job and could not have obtained his present job without it. He enjoys the independence the Optacon gives him.

Respondent #12

Age: 24
Age of onset of blindness: birth
Optacon training center: TSI
Date of training: May 1974

Respondent currently works as a dictaphone typist for the Canadian Government and uses the Optacon about one hour per day. She estimated her reading speed in excess of 20 words per minute and stated that she uses the machine to look up words in the dictionary and to proofread. She believes the Optacon was helpful in obtaining her job. He ability to read print without assistance probably helped convince her employer. She now feels she could not do her present job without the Optacon.

Respondent #13

Age: 46
Age of onset of blindness: 12
Optacon training center: TSI
Date of training: May 1974

Respondent is currently an administrator in a vocational rehab department. He uses the Optacon one-half to one hour per day and estimated his reading speed at 15 - 20 words per minute. He uses the Optacon mainly as a sorting tool for correspondence at work and reads short material, such as one-page memos and correspondence, when his secretary is unavailable. He does not really need the Optacon to do his present job, but feels it makes him more efficient and organized. He likes the added independence it gives him.

Respondent #14

Age: 40
Age of onset of blindness: mid-20's
Optacon training center: unknown
Date of training: summer 1973

Respondent is currently employed as a supervisor of caseworkers in an agency for the blind. He uses the Optacon about one-half hour per day on the

job and estimates his reading speed at 15 - 20 words per minute. He uses the Optacon primarily to sort incoming correspondence, but also reads confidential personnel files. He feels he could handle his job without the Optacon as he obtained the job before obtaining the Optacon. However, he believes he can work more efficiently with it.

Respondent #15

Age: 41
Age of onset of blindness: 21
Optacon training center: TSI
Date of training: January 1973

Respondent works as a high school counselor in California and uses the Optacon about two hours per day. He estimated his reading speed at 25 - 30 words per minute and stated that he uses the Optacon primarily to read books and extended articles to keep himself up to date. For shorter articles, he uses readers and/or his secretary. He feels it would be difficult to work without the Optacon and as his reading speed increases he hopes to use it for more of his job-related reading. He greatly values the independence the Optacon gives him.

Respondent #16

Age: 40
Age of onset of blindness: 36
Optacon training center: self-trained
Date of training: December 1973

Respondent is employed as a counselor in the psychological section of the Veterans Administration. He uses the Optacon three or four hours per day in job-related activities and estimated his reading speed at 60 words per minute. He uses the Optacon to read almost all of his job-related reading as well as material related to his thesis, to draw and read flow charts, and to proofread when he types. He firmly believes he could not do his job without the Optacon as he would be much less efficient and productive. He values the independence the Optacon gives him.

Respondent #17

Age: 39
Age of onset of blindness: birth
Optacon training center: TSI
Date of training: February 1974

Respondent works in the personnel department of a large chain store and uses the Optacon an hour to an hour and a half each day. He uses the machine to read short memos, telephone numbers, and journals such as the Journal of Rehabilitation, and estimates his reading speed at 15 - 20 words per minute. He recently used his Optacon to analyze information on job applications rather than have his secretary do it. Although he had the job before obtaining the machine, he feels he is able to work more efficiently now. He greatly appreciates the added independence the Optacon brings him.

Conclusions

The interviews suggest that the people who are making most effective use of the Optacon on the job are the younger people in entry-level positions. This can be partly explained by the fact that younger people learn to use the Optacon more rapidly. Also, for people in entry level positions, it seems to be more important to demonstrate a capability in advance in order to be able to perform the job with a minimum of additional expense to the employer. Older people have, in general, already worked out alternative methods for obtaining information. They are usually in positions with high enough rank that the employer is willing to spend the additional money for readers or special equipment. These individuals, therefore, do not have the incentive to perform their jobs without special assistance. This implies that those people who are most able and willing to use the Optacon have not been the major group obtaining access to it. It seems imperative to find some means to allow younger people to obtain Optacons; this would permit them to compete more effectively for entry-level positions.

Even for people who are not able to read as quickly with the Optacon, it seems to give them an opportunity to organize their materials and time more efficiently. It permits them to choose which materials to have read or brailled and which to ignore. It also allows them to handle shorter passages of reading independently while their secretary or assistant is working on more lengthy materials. These individuals can deal privately with confidential material which can be of considerable importance to people in senior administrative positions. With these people, the Optacon, although not "necessary", can be a tool which makes it possible for them to become more efficient and more productive employees.

SUMMARY

The first part of this paper indicates that, since mid-1973, more young people have been able to obtain Optacons. This is apparently a result of large-scale Optacon dissemination programs such as that of the Richard King Mellon Foundation. It also indicates that blind people in a wide variety of jobs have felt that the Optacon can significantly increase their efficiency as an employee. This conclusion is substantiated by the interviews conducted with Optacon users. Some of these people indicated that they could not have obtained their present jobs without it. Others indicated that, although not essential to their employment, the Optacon made them more efficient, better organized workers.

These interviews strongly suggest that the Optacon, as an employment tool, cannot be limited to a small set of occupations. Instead, it should be considered as a useful tool in any job where retrieval of printed information is essential.

The statistical section of this paper indicates that young people read more quickly at the end of Optacon training than do old people. The interviews show that young people are also more dependent upon it in their employment. The Optacon has given them the ability to do a job without special concessions from their employer. Many of the people interviewed expressed the belief that this made it possible for them to obtain a job or to advance within their present organization. In short, many young people in entry-level positions have found the Optacon to be absolutely essential.

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